UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURAL MARKETING SERVICE

AMS-469
(Preliminary
Summary)

RAPID VACUUM-COOLING OF LETTUCE

(The following summary of a new method that cuts the vacuum-cooling time for lettuce by about one-third is presented for the immediate benefit of the industry until a more complete report can be prepared.)

Tests at commercial plants show that carton-packed lettuce can be vacuum-cooled to a final tank pressure of 3.8 millimeters of mercury (3.8 mm. Hg.) without danger of freezing and with a saving of about one-third in cooling time, according to scientists of the Agricultural Marketing Service, U. S. Department of Agriculture.

Previously, a pressure of 4.6 mm. Hg. had been considered adequate for efficient cooling. Exhaustion of the air to the lower pressure of 3.8 mm. Hg. brought the lettuce down to an average temperature of 34 degrees F. in about 15 minutes, compared with 23 minutes for the higher pressure.

The saving in time is particularly advantageous during the height of the harvest season when large quantities of lettuce move into the packing plants. There is a tendency during this period to sacrifice some cooling in the interest of moving more volume through the chambers. Speeding the cooling process by improved techniques will result in more thorough cooling, with resultant improved market quality and reduced wastage, according to scientists of the Market Quality Research Division, AMS, who made the study.

The researchers warned that certain conditions of pressure and cooling time must be met for a good cooling job when the new method is used. It is necessary, for example, to use pressure gages more sensitive than those ordinarily used, in order to have a highly accurate knowledge of the pressure within the cooling tank during each run. The cost of such equipment (less than $200) is low, however, in comparison with the advantages from its use. Some semitechnical details of the study follow.

Washington, D. C. March 1962

For this research, the scientists installed a dial-type high-vacuum gage on the vacuum tanks to be studied. This gage, showing pressures in millimeters of mercury (mm. Hg.), was more sensitive and gave much more accurate readings in the low range (0 to 50 mm. Hg.) than the gages usually used.

Thermocouples were used to measure temperatures of the condenser at the inlet and return of the ammonia (in mechanical plants), the temperature of the wet-bulbs in the tank air, and the temperature of the leaves and butts of the lettuce in four cartons. Usually these packed cartons were weighed before and after cooling to relate the amount of moisture evaporated from the lettuce to the drop in temperature.

Cooperators provided facilities for 20 test runs in a mechanical plant, 6 runs in a steam plant, and 6 runs in a unit cooler (mechanical plant). The 20 runs in the mechanical plant included many variations in operating the vacuum cycle, such as "bouncing" the pressure at various times, manipulating the refrigeration for the condenser, and "holding" with vacuum off before the tank doors were opened. Ammonia pressures in the condensers ranged from 19 to 28 pounds per square inch on the gage.

All plants were capable of doing a good job of vacuum-cooling when certain conditions of pressure and cooling time were met.

Minimum pressures.--For a thorough job of cooling carton-packed lettuce in a reasonably short time, it was necessary to pull the tank pressure down to 4.0 mm. Hg. and preferably down to 3.8 mm. At these pressures, the wet-bulb would read 29° and 28° F., respectively, providing the wick did not freeze. The wet-bulb was a good indicator of tank pressures at levels above 4.6 mm. (.18 inch) Hg., the freezing point of water under vacuum, but it became sluggish after the wick froze, and failed to respond fast enough at this point to be useful in regulating the pressure in the tank during the final minutes of the run. No freezing was observed in carton-packed lettuce vacuum-cooled to a minimum pressure of 3.8 mm. Hg.

Time required for cooling.--The tests also showed the need for extra time to cool the butts of head lettuce after the leaves had been cooled to 32° F. It took about 15 minutes after the "flash" to cool the butts to 40° from initial temperatures near 60° (the "flash" is the point in the vacuum cycle when the tank pressure becomes low enough to cause a substantial release of moisture from the lettuce). This was several minutes longer than it took to cool the leaves, the wet-bulb, or a pulp thermometer to 32°. Stopping the vacuum cycle when the pulp thermometer reached 32° gave no assurance that the entire head was cooled to this desirable temperature.

A fast pump-down of the tank from the "flash" to a pressure of 6.0 mm. Hg. helped to speed the cooling of the butts. However, since the speed of exhausting the tank during this period depended upon the capacity and efficiency of the condenser in mechanical plants and the number of "boosters" available in steam plants, a fast pump-down to 6.0 mm. Hg. was not always possible in all tanks and for all vacuum runs.

Since no cooling occurred in the lettuce before the "flash," the faster the pump-down to the "flash," the shorter the total time needed for the vacuum-cooling run. Faster initial evacuation was possible in all mechanical plants by turning the refrigeration on in the condensers immediately.

Final temperatures vs. quality.--The butts of the lettuce had to be cooled to at least 40° F. to obtain an average temperature of 34° or lower for the entire head. In tests run by Dr. W. J. Lipton last fall, carton-packed lettuce vacuum-cooled to 34° and held 9 days at this temperature had less decay and less russet spotting than similar lots vacuum-cooled to 38° and held at 38°, or others packed with crate ice and held under top ice. The lots vacuum-cooled to 34° also held up better during 3 additional days at a retail display temperature of 50°.

Cooling in various positions in load.--In tests to determine the effect of position of cartons in the load on the rate of cooling the lettuce in vacuum tanks, top-layer cartons cooled faster than those down deeper in the pile. No consistent

differences occurred in the rate of cooling in cartons distributed lengthwise of the load in the same row and layer. These findings indicate that the vents as arranged in the present cartons may be blocked on the pallet stacks and thereby restrict the evaporation of moisture from the lettuce and the resulting cooling.

Condenser temperatures.--In the liquid ammonia condensers studied, there was no correlation between the theoretical temperature of the condenser, as judged by the gage on the ammonia line, and the actual temperature at the surface of the pipes.

Frequently much of the condenser surface was above freezing and was dripping water during most of the vacuum run, despite the subfreezing ammonia temperatures indicated by the gage. Such a condition retarded cooling by placing an extra vapor load on the pumps. At all times the surface of the inlet pipes was considerably warmer than the indicated ammonia temperature. Usually the average temperature of the pipes was not below 28° F. at the time the operator turned the refrigeration off to prevent the tank pressures from dropping too fast. A 28° condenser temperature was found safe for lettuce in the pilot plant at Fresno, as reported in USDA Marketing Research Report No. 469, "Factors Affecting Temperature Reduction and Weight Loss in Vacuum-Cooled Lettuce."

With thermometers installed on the condenser pipes to obtain true surface temperatures, the operator could turn the refrigeration off and on as needed for cooling the lettuce in the shortest time. This method of controlling the temperature of the condenser probably would be more effective and cheaper than adding a pressure control valve to the ammonia line.

###